Practical HF broadband wire antennas

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Early in my training I was taught that an antenna must be cut and tuned to a multiple of a quarter wavelength, if it is to radiate efficiently. That statement still holds true but we can bend the rules and trade a bit of the efficiency for bandwidth when we need it. Such is the case with the lengths of wire described here. All are proven in commercial installations I have engineered here and there along the track. Back in the 80s I used to make up and sell a 'Starters Kit' for those wanting to likewise dabble. These days you are on your own!

Why broadband?

Modern high frequency radio communications networks demand great flexibility in antenna design. Channel scanning, frequency hopping and cross band working all call for antennas that have to work instantaneously over a very wide bandwidth, sometimes the complete HF spectrum.

Why wire?

Wire antennas are generally simple to erect. They can often be supported from existing masts, trees or buildings and a multitude of designs can be constructed that will satisfy the broadband requirement. These can be as elaborate as a 'Rhombic' or 'Vee Beam', or as simple as a 'Dipole' or 'Long Wire'.

Antenna or dummy load?

While they come in many shapes and sizes, the configurations briefly outlined here are all classified as 'Travelling Wave' Antennas (TWAs) and to be more precise, 'Ground Terminated' TWAs. They have also been called 'Radiating Dummy Loads' by the unkind, which carries a small degree of truth when the size is restricted. To be efficient for transmitting, particularly on the lower frequencies, 'big is beautiful' and they require a rather large amount of 'Real Estate'. However, they can be designed to be directional and have quite reasonable gain. Another very favourable feature is that they generally present a stable load for the transmitter driving them, resulting in a maximum transfer of power, a cool transmitter and clean transmission.

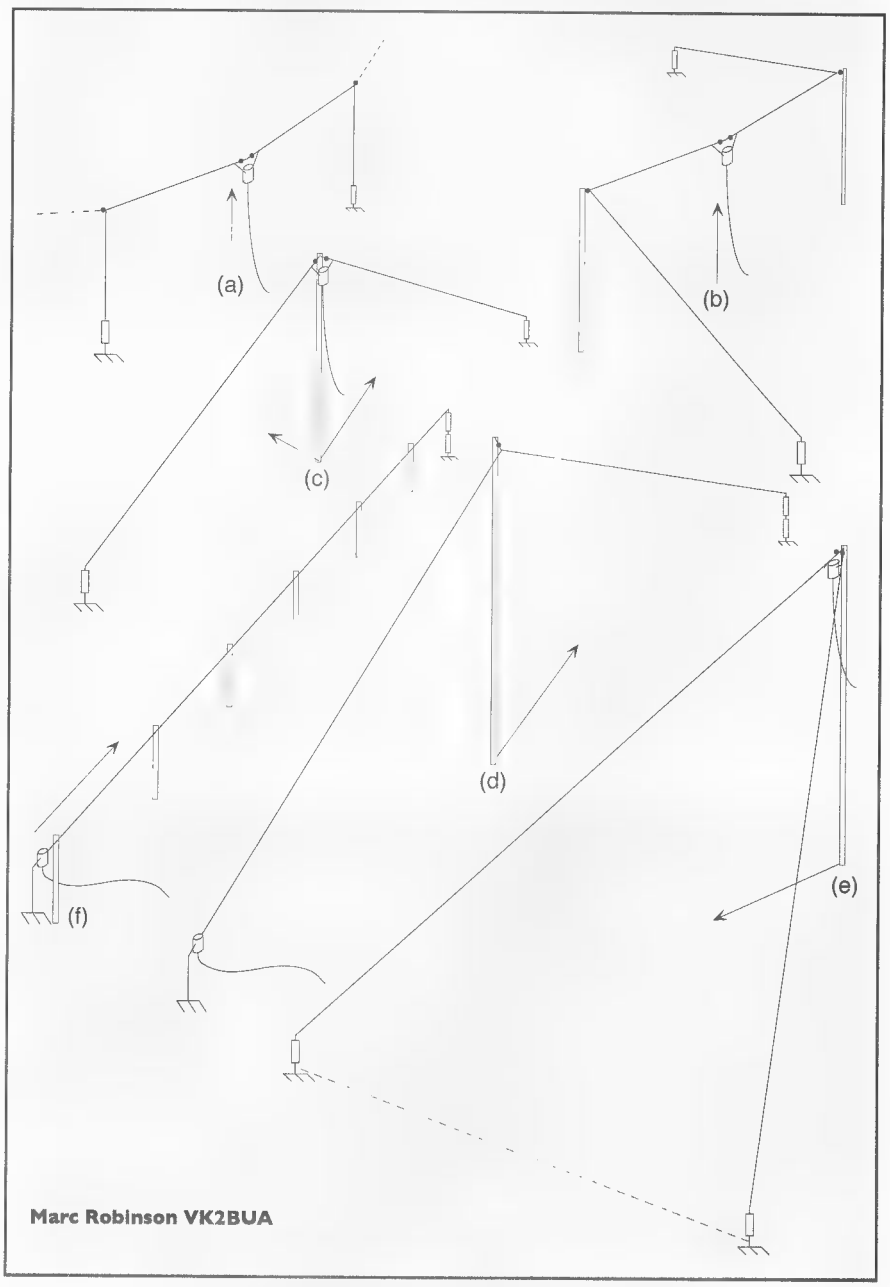

Fig 1 – A few practical wire antennas (see text).

Reception?

Ground terminated TWAs make very good receiving antennas because the terminations prevent any static build up on the antenna wire, keeping the noise level low.

Which antenna?

While 'boffins' might at this point get out a site plan and run up their PC antenna simulation programs to come up with the perfect design, Figs 1(a) to (f) give a few practical designs. Suggested dimensions are all 'very flexible' and can be varied by 20% or more without worry.

(a) illustrates a centre fed dipole strung between two supports, masts, trees, etc. The ends of the dipole are dropped vertically to ground level where each connects via a 'Terminator' to ground. Suggested dimensions for 2-30 MHz operation are 35 m (115 ft) across the top with 15 m (50 ft) down drops. This antenna is basically omni directional, providing high incidence radiation at lower frequencies for local working out to about 1500 km or 950 miles and higher frequency low angle radiation beyond.

(b) is the same antenna, but with the down drops taken out in some direction beyond the supports. This is a way to extend the length of the antenna and so improve performance on 2 MHz frequencies and lower. Don't lengthen the down drops to more than about twice the support height.

(c) is a centre fed inverted vee configuration. It may be more practical to have one taller mast, say 30 m (100 ft) rather than two smaller ones like in (a) and (b). Each leg length should be about twice the mast height. Radiation is omni directional at the low frequencies, becoming bidirectional as the frequency increases.

(d) uses the same physical construction and dimensions as (c) but the feed point is shifted to one end and the other is terminated. Radiation is in a direction away from the feed point towards the terminators. This antenna is effectively a vertically polarized 'Half Rhombic', with the missing half being mirrored by the 'ground'.

(e) is also a 'Half Rhombic', this time horizontally polarised and commonly known as a 'Vee Beam'. Mast height should be as high as possible to keep the vee as steep as possible, resulting in low angle radiation for long distance working. A good apex angle for the vee is 60 degrees with maximum radiation from the vee opening. Six legs could be arranged symmetrically from a single centre pole, preferably on high ground with the legs dropping down to lower ground. Relay switching could select pairs of legs in turn to form a 360 degree steerable antenna.

(f) is a form of 'Beverage,' more suitable for reception than transmission. It consists of a single wire run 1 to 2 metres off the ground along a fence top for quite a long distance, say 50 to 500 m. This antenna receives very well at LF and medium wave where it is directional from the feed point to the terminators. At HF it radiates almost directly upwards, depending up earth conditions beneath it.

Key components

Two essential items are needed to put any of these antennas together:

The first is a 50 to 600 ohm IsoTran (Isolating Transformer) - see Fig 2 - with a power rating to suit the transmitter output. Depending on the design, a TWA will generally have a feed impedance between 450 and 750 ohms, so 600 ohms is a good compromise. Why not a Balun (Balance to Unbalanced) transformer which is so commonly used to couple a coaxial cable to a balanced antenna? The balanced winding of a Balun effectively has a centre tap connected to the braid side of the unbalanced winding. This presents no problem when the antenna is constructed with perfect symmetry, both legs of the same length, no objects close to one leg and not the other, etc. Many of the antennas described here are unbalanced because of odd leg lengths or ground terminations. Any antenna imbalance causes out of balance currents to flow through the local ground system and back along the braid of the antenna coax, inducing noise or RF radiation. For this reason a Balun is not recommended. A much better choice is an IsoTran with isolated primary and secondary windings of the correct ratio. This allows the Antenna to 'Float' and take up a natural balance above ground without inducing currents into the coax feed line.

The second item is a pair of 300 ohm non inductive wire wound resistors (Terminators) which are used to terminate the far end of each leg of the antenna to ground, hence the 'Dummy Load' analogy. Note that in the case of end fed models, both terminators are connected in series to ground at the far end of the antenna. Each 'Terminator' should have a wattage rating of at least

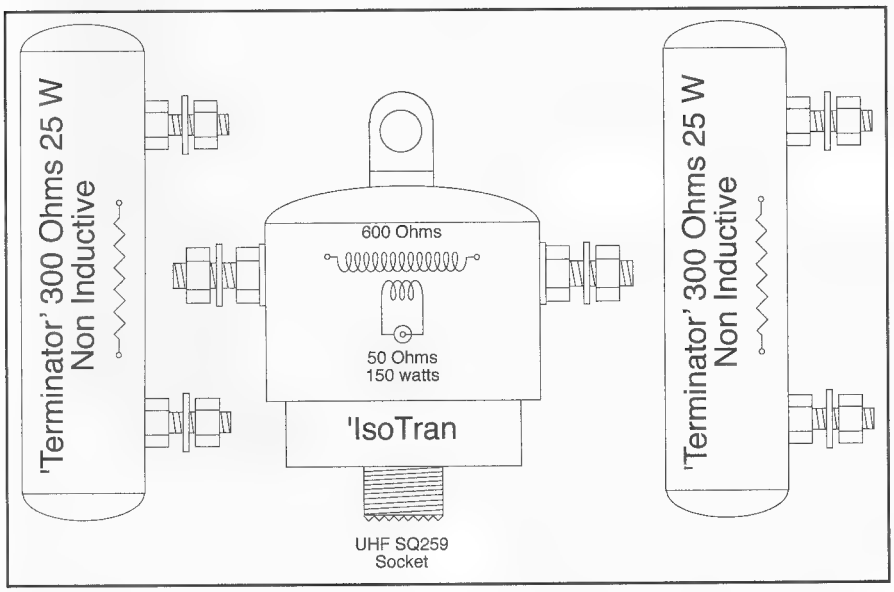

Fig 2 – A little starter kit I used to make and sell under my IsoTran brand back in 1980-90. I'm sure alternatives can be sourced or made up to suit.

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20% of the transmitter PEP for voice transmissions or 40% for continuous data. The amount of power dissipated in the 'Terminators' depends on the length of the antenna and the frequency in use. The shorter the antenna or lower the frequency, the more the 'Terminators' become the 'Dummy Load'. CAUTION: they could become a fire hazard if they overheat from excessive transmitter power and so, must be positioned and supported appropriately.

Other bits and pieces

What to make the antenna from? A visit to your local boating warehouse should provide the answer. You can't go wrong using very flexible small diameter stainless steel wire rope. Don't let anyone tell you that stainless has too higher resistance. A 2.5 mm (3/32 in) 7x19 strand stainless rope has a lot more surface area for RF to flow on than single or seven strand hard drawn copper wire. What's more, it is far more flexible and has a breaking strain around 420 kg or 990 lb. You will need a quantity of 2.5 mm copper swages, a hand held swaging tool and a 'Parrot Beak' wire rope cutter. The tools are a bit expensive but once you have used them, you won't go back to copper wire, wrapping and soldering. The same warehouse should also have a good selection of pulleys and 'UV proof' nylon rope to support the antenna. Pulleys and counterweights are essential to avoid damage when the supports are trees that sway in the wind. A good counterweight is a sturdy plastic bucket with a few holes drilled in the bottom so it will drain, filled as necessary with sand and rocks to tension the antenna. You will need to source a supply of strain 'Egg' insulators and ground stakes and clamps (probably from your local electrician).

Coax cable

I won't go into too much discussion on coax cables and connectors, except to say; don't hang the down drop of coax from the IsoTran by its connector. Loop and tie the coax through a spare 'Egg' insulator before fitting the connector and hang the insulator and IsoTran from the antenna, between the two centre insulators. Use RG58C/U coax cable with a stranded centre conductor for receivers or transmitters up to 400 watts, or RG213 for higher power or runs longer than 30m. Only use coax connectors which have a soldered centre pin and sealing gland that does up on the outer braid and sheath. Have self amalgamating tape ready to weatherproof them.

Rigging

Antenna assembly is relatively easy when using stainless wire and swages. It's a matter of slipping a swage onto the wire, threading the wire around the insulator and back through the swage. Leave more than enough tail to go to the IsoTran or Terminator, slip the swage up close to the insulator or thimble and crimp with the swaging tool. To terminate the tail on the IsoTran or Terminator, form an eyelet by pushing the wire through a swage and then back on itself. Make the eyelet a snug fit on the terminal before crimping the swage. By now you will probably have stuck yourself a few times with the sharp ends of the wire strands. Tape the ends so you don't catch your fingers further when rigging the antenna. If you have a 'Sea Scout' or 'Ancient Mariner' in the team, tying off or splicing the nylon rope on the insulators will be no big task, otherwise pick your best knot and hope it holds. Always melt the nylon end strands of the rope tails to prevent them fraying and unraveling. (A cigarette lighter and glass of water required). Don't touch the molten nylon unless the team includes a doctor.

Grounding

Since the Terminators themselves are 300 ohms, the resistance of the ground connections for these antennas is not as critical as it would be for say, a quarterwave ground plane antenna, where the base impedance may be as low as 10-20 ohms. Nevertheless, a few rules must be applied. Don't elevate the Terminators. Keep them low to the ground and the lead to the ground stake or buried ground wires should not exceed 1 m or 3 ft. Likewise for the IsoTran on end fed antennas where one side of the 600 ohm winding of the IsoTran must be grounded. In dry ground use multiple ground stakes or run a buried ground wire between the two Terminators at each end of the antenna.

So, go pull up some wire!

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